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FOREIGN TECHNOLOGY DIVISION

"INTERCOSMOS" PROGRAM

By

D. Felske, H. J. Fischer and K. H. Schmelovsky

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"INTERCOSMOS" PROGRAM

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In the contribution submitted an introduction will be given , with the help of several examples, into the significance of the "Cooperation of socialistic countries in the sphere of exploration and the peaceful utilization of cosmic space" arranged in 1967. The cooperating collectives of the DDR involved have gathered first experience in active experiments as well as in earth observation programs in a coordinated fashion. A close cooperation between theory and practice, between geophysics, electronics and data processing rapidly led to internationally noticed results.

We are especially happy that the scientists themselves actively involved in the projects concerned are ready to report on this for our readers.

(Ed.)

Physical Objectives of the Experiments

In the last year the effect of the sun on the earth has been the topic of intensive investigation. The questions concern the physics of the sun - e.g. clarification of the operating mechanism of the sun as well as practical problems such as worldwide travel, high-altitude communications or telecommunications engineering. One can obtain complete cognizance of the environmental effect on people only through directed objectives of major research; outer-space research is an essential branch of this.

The experimental Intercosmos 1 (IC - 1) and 4 (IC-4) were concentrated on the exploration of solar processes and effects while the experimental Intercosmos 2 (IC -2) was for ionospheric research.

A coordinated earth observation, Cosmos 261, already begun will carry

on and direct the designated experiments from the beginning to a correlation to the measured parameter. This is much easier to plan than are measurements encountered later.

Since the satellite serves, so to say, as "vehicle" for a series of experiments, it must be oriented to the sun for solar research while for ionosperic purposes it can be used unstabilized. During the active lifetime of the satellite - about 4 months - the results of measurements by the sensors on board will be carried over a telemetry path to the appropriately equipped earth stations and be available in the form of an analog or digital recording.

To study the short-wave radiation of our sun one must place sensors outside the earth's atmosphere because the known spectral range is impermeable to the earth's atmosphere. At present the following areas are particularly intensively under observation:

- active areas of the sun
- persistent sources of particle emission
- sources of sporadic eruptions of energetic particles and of solar plasma
- UV, X-ray and microwave radiation of the sun
- temporal changes of solar actively over extensive periods of time and prognostic methods

In the area of ionospheric research the following are of current interest:

- local and integral measurement of electron and ion concentration in the high altitude region, 200-600 km
- measurement of the structure and dynamics of the ionosphere by correlation of satellite and earth measurement methods
- measurement of electron and ion temperature along the line of flight of the satellite

Some of the details which assist in the experiments of IC - 1 and IC - 4 will be introduced. The following measuring instruments are installed aboard this satellite:

1. optical photometer for about 6,100 Å (ČSSR)
2. Lyman - Alpha -Photometer for 1,215 Å (DDR)
3. X-ray spectral analyser in the energy range 5 - 100keV (ČSSR)
4. X-ray spectroheliograph (UdSSR)
5. X-ray polarimeter for 0.6 - 0.9 Å (UdSSR)

Measurement of the integral flow in many spectral regions or localization of active areas by scanners are possible simultaneousely with this equipment.

An additional measurement method is by absorption spectroscopy. By this, the parameters of the upper atmosphere are measured at the same time as the sun is used as the light source and the absorption of its radiation on passage of the satellite in the shadow of the earth is ascertained.

The transparency of the earth's atmosphere in high-altitude regions, 15 - 100 km, are measured with the optical photometer; in the highest strata meteor dust is present. By correlation of this measurement with the Lyman -Alpha measurement one can indirectly determine the composition of the upper atmosphere. In the Lyman -Alpha range the components O_2, NO and N_2 and only O_2 and N_2 in the range of 8 - 16 Å. Both Soviet instruments, X-ray spectroheliograph and X-ray polarimeter serve to measure and localize the dynamics of X-ray radiation sources on the sun. Polarization measurements also give, in addition, information about the possible effect of a magnetic field or nonthermal cause of the generation.

The spectroheliograph produces a "picture" of the active regions by scanning the spectral region 8 - 14 Å by means of two slits which are perpendicular to one another with a resolution of 0.3′ X 0.3′. The X-ray polarimeter works in the area around 0.8 Å with a beryllium diffusor and proportional Geiger counter.

Joint evaluation of the measurement results of these international experiments resulted in a series of interesting scientific findings which were published in the appropriate specialty journals.

Technical Objectives of the Experiments

In detail, the following basic requirements of the task are:

1. Development of physical sensors (ionization chambers, Geiger counters, scintillators, half-life detectors, etc.) and the pertinant adaption electronics as well as an electricity supply appropriate to the great demand required by this type of equipment.
2. Integration of all pieces of equipment into a "scientific complex" and structural accomodation to the satellite.
3. Production of a real-time telemetry system of FM/PM category (frequency modulation/phase modulation) on board as well as on earth.
4. Gain of experience on how the environment affects the instruments.

The standard satellite (Fig. 1) has three parts: the upper hemisphere with scientific instruments in the inner and the sensors on an outer platform, the cylindrical part with the service system (telemetry, telecommand, on board storage) and the lower hemisphere with the electrical supply system. On the upper surfaces of the cylindrical part are housed the solar panels, the sun sensor, the executing agents of the orientation systems and the antennae. The position control of the satellite at its orbital movement results with the help of a flywheel and gas jet repulsion nozzle. Fig. 2 shows the satellite with the solar panels completely opened out and, in the bottom viewm one sees the antennae assembled on the back side of the solar panels. The inner space of the satellite is hermetically sealed and equipped with a thermoregulatory system. High demands are placed on the equipment aboard the satellite especially in regard to :

- small volume and weight
- vibration and shock resistance
- temperature and radiation resistance
- low energy consumption
- high operating reliability

In order to produce reliable on board equipment reliable technology in manufacturing as well as in testing is required. The construction is of light metal housing: it has printed wiring and a silicium semi-conductor installed. As an example of the on board equipment the X-ray photometer

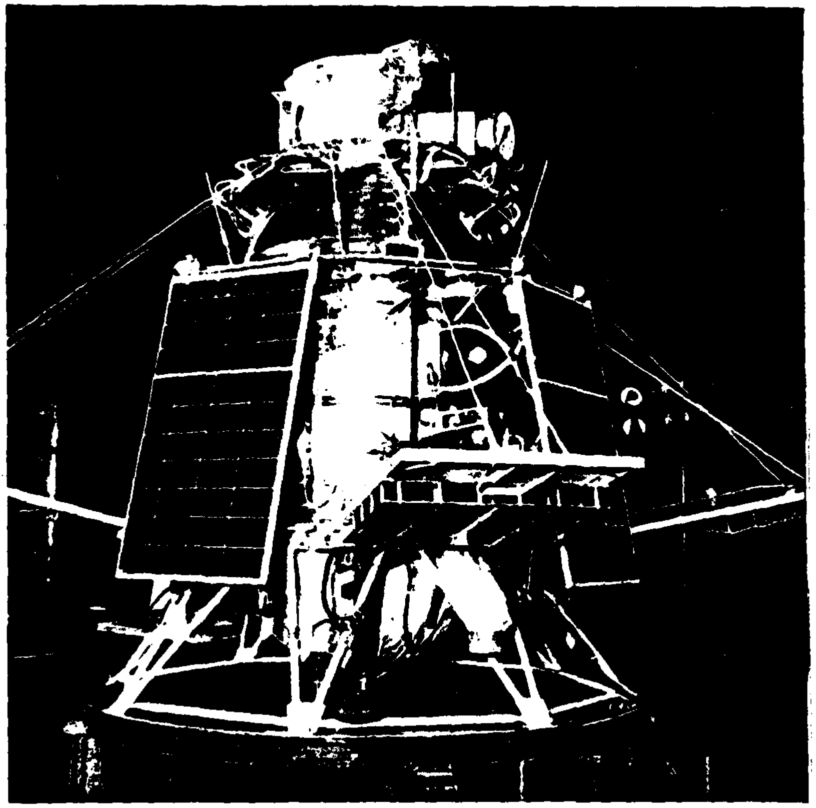
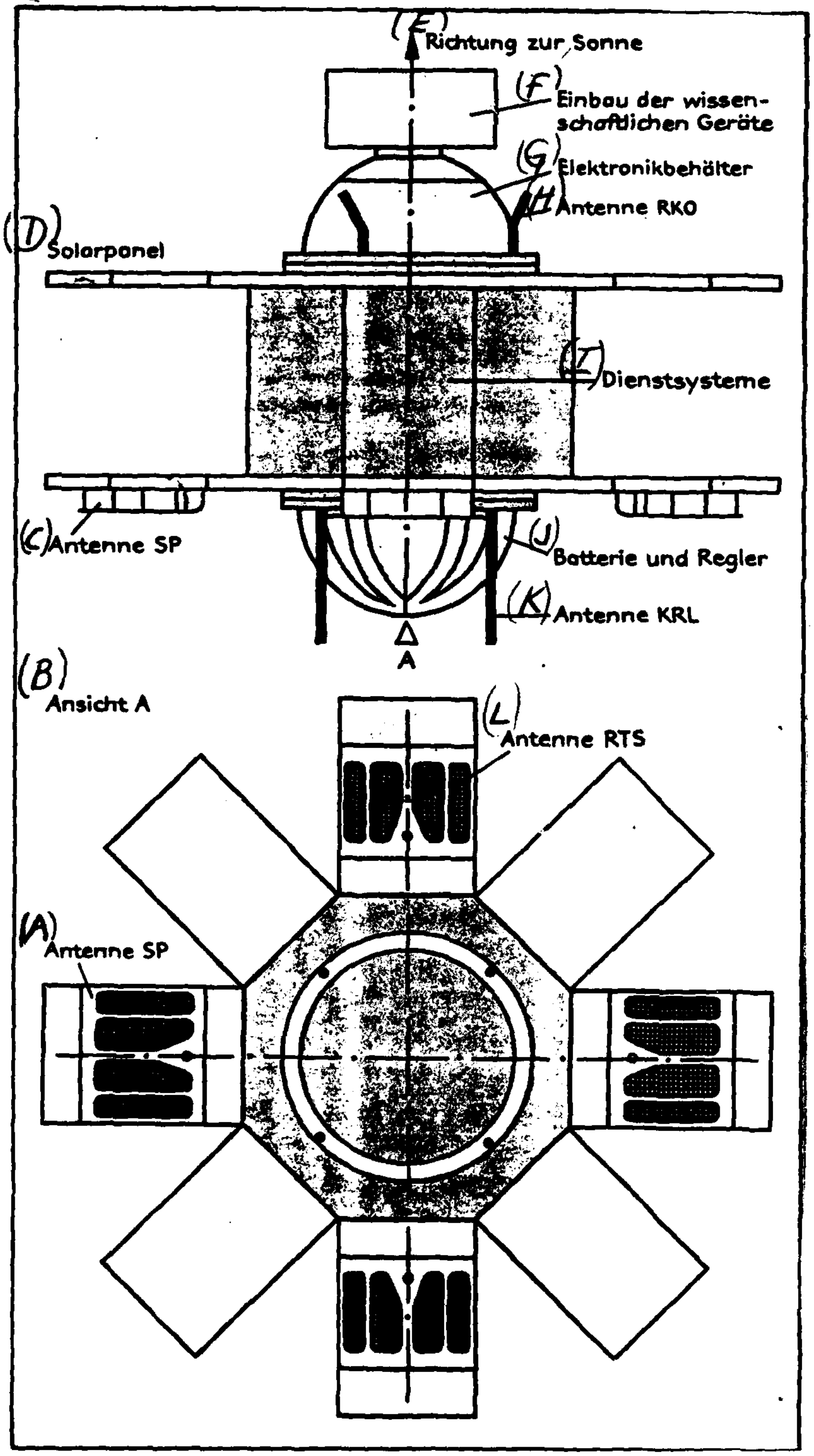


Fig. 1. General view of the satellite Intercosmos 1 at assembly; solar panels partially tilted out.

and the Lyman - Alpha Photometer are displayed here. Fig. 3 shows the X-ray photometer developed through the cooperative work between Tesla VUST Praha and the Astronomical Institute of the Academy of Science of the ČSSR with amplitude discriminators for 7 energy bands.

The instrument on the right - the sensor block - operates in a vacuum, both instruments to the left of it are in the interior of the satellite. That on the left outside and in the middle are the electronic block and the storage instrument, respectively. The measurement equipment is joined to the satellite with a plug and socket. There are more than 200 transistors in the instruments and a large number of passive components are built in.



A. Antenna, Solar Panel
B. View A
C. Antenna, Solar Panel
D. Solar Panel
E. Orientation to the sun
F. Installation of scientific instruments
G. Electronic container
H. RKO antenna
I. Service system
J. Battery and regulator
K. KRL antenna
L. RTS antenna

Fig. 2. Sketch of the shape of the satellite with solar panels completely opened out.

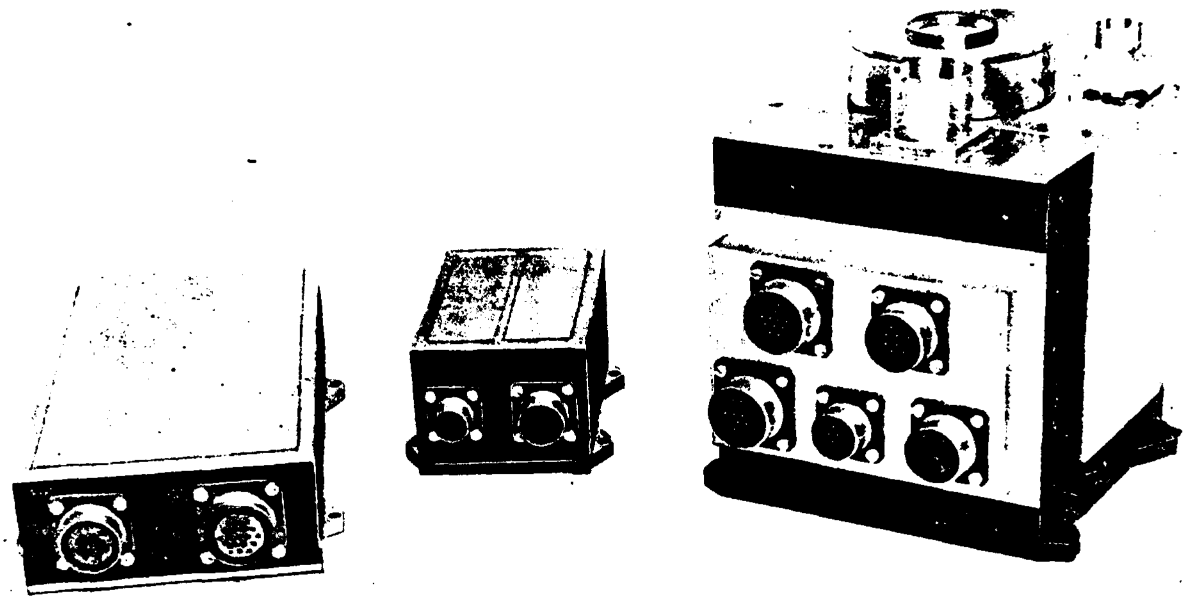


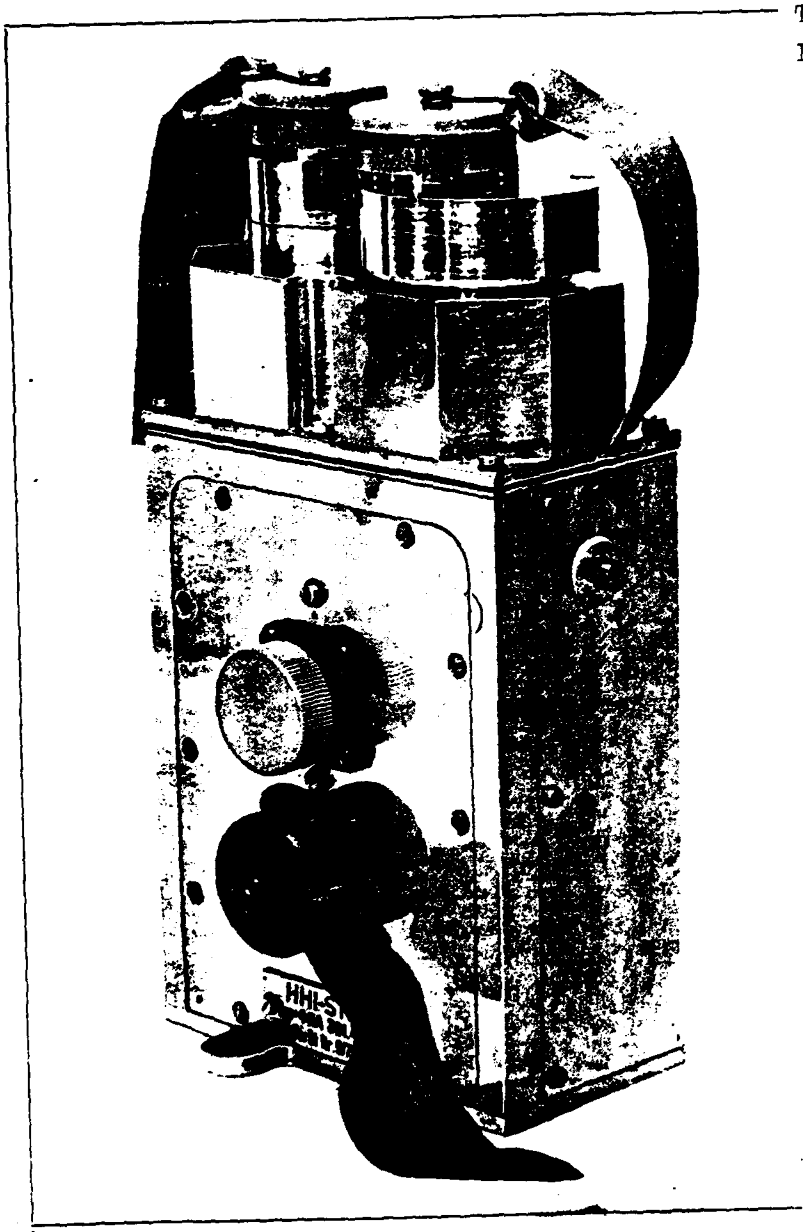
Fig. 3. Seven channel X-ray photometer (ČSSR)

The necessarily high operating reliability of such complex equipment requires considerable technical expenditure.

Fig. 4 shows the structure of the Lyman - Alpha Photometer that was developed at the Central Institute for Solar Terrestrial Physics of the DAW in Berlin. This equipment also operates in a vacuum and was constructed for these difficult conditions. The radiation sensitive element is a special ionization chamber - likewise, a singular development. The strengthening of the extraordinaryily small direct current for transference of increasing quantities presents a difficult technological problem. It was solved by close cooperation of all parts. A power pack is part of this equipment which is found in the interior of the satellite, as well as a sender for direct transmission of measurement data.

A further technically difficult problem is the interference free

Fig. 4. Photometer for measurement of solar Lyman -Alpha radiation (Central Institute for Solar Terrestrial Physics of the DAW, Berlin)



cooperation of all equipment pieces in a complex of the satellite. The necessary attempt at cohabitation causes frequent occurence of disturbances which can be eliminated only by intensive cooperation by all experimentors.

Observatories in the UdSSR, the DDR, the ČSSR and the VR Bulgaria

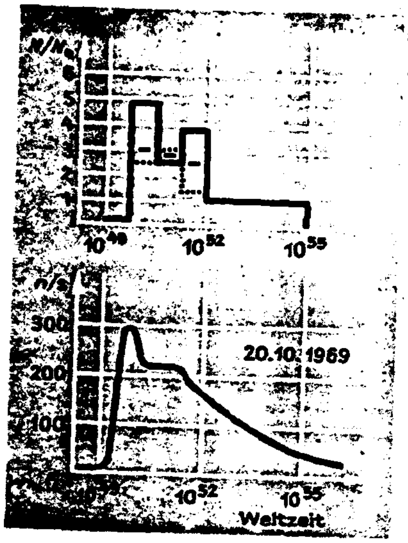
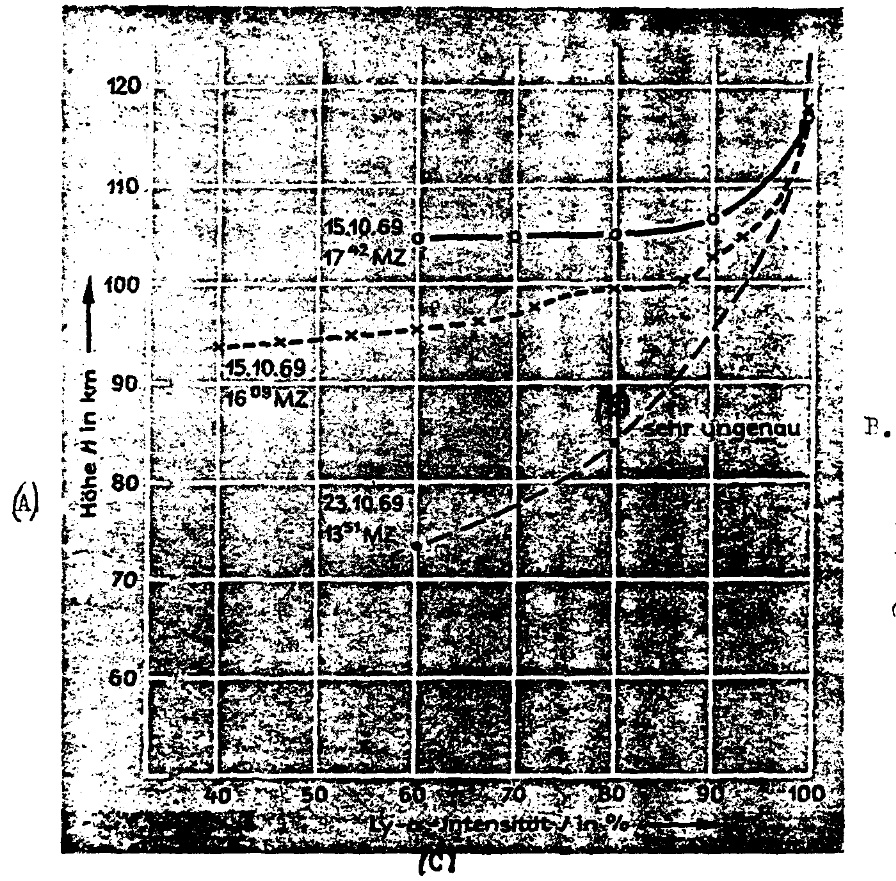


Fig. 5. Measurement results of X-ray polarimeter aboard the Intercosmos 1 (UdSSR)

participated in ground observation. In addition, a series of other observatories, e.g. in Rumania and Cuba carried out observations according to a program tuned to "Council on Sun - Earth" of the Academy of Science of the UdSSR.

Scientific Results of the Experiments

The equipment on board the satellite *IC* - 1 recorded a series of interesting phenomena of special X-ray eruptions on the 20th, 22nd, 23rd and 30th of October 1969. At three outbreaks of this kind an X-ray polarimeter developed in the UdSSR fixed at a wavelength of 1Å established a degree of polarization of P = 0.4 ± 0.2 with a probability of 0.9. Fig. 5 shows the most important results. In the upper part the normal rate of counting of the polarization - porportional counter and in the lower part the rate of counting of the patrol counter. They reproduce the integral course of the eruption. These values were measured on October 20, 1969. The dotted values in the bar in the upper part show the degree of polarization (in unpolarized radiation the dotted value must coincide with the continuous values). As one



A. Height H in km

B. very inexact

C. intensity

Fig. 6. Absorption curves of Lyman - Alpha radiation in the upper atmosphere (Neustrelitz Observatory of the Central Institute for Solar - Terrestrial Physics).

can see, the greatest amount of polarization coincides with the greatest intensity. One can explain this by non-thermal generation mechanisms, probably as retarding radiation of the directed electron current. Since one requires statistical material these measurements were carried out on the IC - 4.

With the help of the X-ray spectroheliograph from the UdSSR the shape and structure of the X-ray flares are measured simultaneously. The flares were found to have a filamentous-shaped structure with a length of 1 angular minute

and a width of 10 - 20 angular seconds. The structure of the flare quickly changed, the temperature in the interior of the flare region is higher than 20 million degrees K; the density of electrons comes to 10^{10} electrons for every cubic centimeter.

With the help of a Lyman - Alpha Photometer the average flow of the radiation was determined at 3.7 - 4.7 erg/cm^{2}s at a wavelength of 1216 Å. Furthermore, the density of molecular oxygen on the entry of the satellite into the earth's shadow was determined below an altitude of 120 km. The best of these measurements took place on October 15, 1969 at 2:09 p.m. GMT at a latitude of 40°. It produced the most important result in that the measured density is smaller, by a factor of 2 - 3, than is given in the CIRA atmosphere model. Fig. 6 shows the experimentally obtained absorption curves in the graph of I = f(h). In consideration of a possible mistake in the altitude of ± 5 km the experimental proof of a low concentration of O_2 is regarded as secured. This is confirmed by results of the rocket measurements of Wildman in Australia (1969).

The results of the optical photometer (ČSSR) show agreement of the results of absorption measurements with the calculated values. On the 23rd of October, at an altitude of 70 km, an anomaly was encountered, i.e. the permeability was less than 5%. This is associated with the presence of meteor dust of Orion which was at a maximum on the 22nd of October.

The X-ray photometer (ČSSR) recorded interesting relationships between chromospheric eruptions and ionospheric disturbances. It was determined to be a time shift between the recording of the X-ray outbreak by the satellite and of the influence of the ionosphere. The results obtained are important for understanding longitudinal wave propogation.

Likewise, interesting results are transmited by the IC - 2 and particularly through the ionosphere in the altitude range of 200 to 1,100 km. Data was collected about the ion concentration and electron temperature during 100 orbits. Evaluation showed a concentration of charged particles along the path of the satellite of $2 \cdot 10^4$ cm^{-3} to 10^6 cm^{-3} : the electron temperature lay

between 800° K and 3,000° K. Along with the local electron concentration measured by probes, the integral electron density by sensing of the two coherent frequencies of 20 M Hz and 30 M Hz and the evaluation of the amplitude and phase changes of the received signals (with the help of the sender "Majak" developed in the DDR) as well as the measurement of the Faraday Effect, were determined.

The evaluation of further measurement results of the active experiments resulted by the appropriately appointed plan of the cooperation in the indivdual subscribing countries.

The scientific and technical results from the cooperative experiments carried out by the socialistic countries for exploration and utilization of cosmic space furthers our knowledge about the environment and provides a starting point for the industrial utilization of the technical experience gained.

The bibliography will gladly be sent to our readers if desired. (Ed.)

Advancement of Science in the Soviet Union

Statistical data which were published recently in the Soviet Union show anew what significance is attached to technical scientific development. The rate of growth of the number of all workers in the UdSSR from 1961 to 1966 amounted to 4.3%. The corresponding numerical value, in comparison, of all in research activities lays, in the same space of time, essentially 7.7% higher. At present, about 2.7 million Soviet citizens work in research; that corresponds to a portion of about 3.4% in the total occupational activities of the population. The investment in research is also very considerable. 7.9 million rubels were given for this purpose in 1968. This was 10.8% more than the corresponding sum in the previous year!

Jovian Spot "Whirls"

For a long time man has observed the so-called red spot in the atmosphere of the giant planet Jupiter about which scientists are still not clear. Nevertheless, this red spot has a dimension which it clearly conveys to our

earth. Newest research results from Reese and Smith of New Mexico University now indicate, as communicated in the journal "Bild der Wissenschaft" Volume 7/1969, that the whirling must be regarded as a tremendous whirlpool phenomenon. Up to now the view adopted was that the red shape was some sort of propelling body in the atmospheric layer. Observation by the above mentioned scientists tracked small black spots in the surrounding, rapidly expiring rotating area of the atmosphere of Jupiter. In addition, it is clearly established that these spirals in the red spot are involved. In this way even the rotation time of the whirl can be at least approximately *be* determined. According to this, it lies between 9 and 12 days.

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